Attachment B

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT'S EVALUATION OF ABENGOA BIOENERGY BIOMASS OF KANSAS, LLC PROPOSED BACT OPTIONS

Abengoa Bioenergy Biomass of Kansas (ABBK) conducted a BACT analysis to determine the appropriate control of emissions from the proposed biomass-to-ethanol and biomass-to-energy production facility. This facility will consist of the emissions sources listed in Table B-1.

The following represents the KDHE's evaluations of the proposals for BACT supported by a summary of the analysis done for each control option. Please refer to the BACT analysis in the following application documents: *2011 Updated Facility Design Prevention of Significant Deterioration, Air Quality Construction Permit Application Supplement – Source ID No. 1890231* dated May, 2011 for a more thorough evaluation of possible BACT.

Table B-1. Emission Units and Pollutants Subject to BACT and PSD-BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-11120	Floor Sweep System DC	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.0007 gr/dscf	
EP-11110	Bale Grinder DC	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.0007 gr/dscf	
EP-11170	Classifier Cyclone # 1 DC	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.0007 gr/dscf	
EP-11270	Classifier Cyclone # 2 DC	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.0007 gr/dscf	
EP-11711	Boiler Feed System DC	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.0007 gr/dscf	
EP-20514	Boiler Bottoms Ash Handling DC #1	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	

Table B-1. Emission Units and Pollutants Subject to BACT and PSD-BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-20510	Boiler Fly Ash Handling DC #1	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	
EP-20520	Boiler Fly Ash Handling DC #2	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	
EP-20512	Lime Handling DC #1	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	
EP-11110FUG	Crop Grinding and Conveying	$PM/PM_{10}/PM_{2.5}$	None	Total Enclosure Utilizing Fabric Filter Baghouses
EP-11110FUG	Crop Residues and Energy Crops Receiving Via Truck	$PM/PM_{10}/PM_{2.5}$	See Area 11000	Good Work Practices
EP-02710	Bulk Fly Ash Load-Out Silo	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	
EP-02711	Bulk Fly Ash Load-Out Silo Spout	PM/PM_{10}	0.004 gr/dscf	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 gr/dscf	
EP-18185	EH Fermentation CO_2 Scrubber	Condensable PM	0.1 lb/hr	Wet Scrubber
		NO_2	0.08 lb/hr	Wet Scrubber
N/A	EH Distillation Vent Scrubber (S-18180)	Ducted to EH Fermentation CO_2 Scrubber, EP-18185 for additional control. See EP-18185.		

Table B-1. Emission Units and Pollutants Subject to BACT and PSD-BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-20001	Biomass-Fired Stoker Boiler	Condensable PM	0.017 lb/MMBtu	SDA with Fabric Filter Baghouse
		Filterable PM	0.015 lb/MMBtu	Fabric Filter Baghouse
		Filterable PM_{10}	0.013 lb/MMBtu	Fabric Filter Baghouse
		Filterable $PM_{2.5}$	0.011 lb/MMBtu	Fabric Filter Baghouse
		NOx (Including Start-up/ Shutdown/Malfunction)	0.30 lb/MMBtu (30-day rolling)	SNR with OFA and Good Combustion Practices
		NOx (Including Start-up/Shutdown, Excluding Malfunction)	150 lb/hr (1-hour average)	SNR with OFA and Good Combustion Practices
		SO_2 (Including Start-up/ Shutdown/Malfunction)	0.21 lb/MMBtu (30-day rolling)	Injection of sorbent (lime) in combination with a dry flue gas desulfurization (FGD) system.
		SO_2 (Including Start-up/ Shutdown, Excluding Malfunction)	106.2 lb/hr (maximum 1-hour)	Injection of sorbent (lime) in combination with a dry flue gas desulfurization (FGD) system.
		CO	260 ppmv @3%O_2	Good Combustion Practices
EP-04001	Cooling Water Tower	$PM/PM_{10}/PM_{2.5}$	1,575 ppm TDS	Drift Eliminator with 0.0005% Drift Rate

Table B-1. Emission Units and Pollutants Subject to BACT and PSD-BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-09001	Flare	$PM/PM_{10}/PM_{2.5}$	None	Smokeless Design
		NOx	0.33 lb/hr 0.12 ton/yr	Low NOx Burner
		SO_2	≤100 ppm Sulfur by Weight	Treated Biogas and Pipeline Grade Natural Gas Only
		CO	1.76 lb/hr 0.48 ton/yr	Good Combustion Practices
EP-06001 (EMG)	Firewater Pump Engine	$PM/PM_{10}/PM_{2.5}$	0.08 g/Hp-hr	EPA Tier 3 Standard
		NOx	2.57 g/Hp-hr	EPA Tier 3 Standard
		SO_2	≤0.0015% Sulfur by Weight	Ultra Low Sulfur Distillate Oil
		CO	0.67 g/Hp-hr	EPA Tier 3 Standard
EP-01000	Paved Haul Roads	$PM/PM_{10}/PM_{2.5}$	148 Trucks/ Day 7-Day Rolling Average (44 Trucks 6pm-6am	Truck traffic fugitive control strategy and monitoring plan, including sweeping and speed limits
EP-01000	Paved Haul Roads	$PM/PM_{10}/PM_{2.5}$	Annual Maximum: 47,852 trucks and 14,356 trucks between 6 pm-6 am	Truck traffic fugitive control strategy and monitoring plan, including sweeping and speed limits

Table B-1. Emission Units and Pollutants Subject to BACT and PSD-BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-01050	Biomass Laydown Roads	$PM/PM_{10}/PM_{2.5}$	109 Trucks per Day 7-Day Rolling Average	Truck traffic fugitive control strategy and monitoring plan, including sweeping and speed limits

I. BACT ANALYSIS OF COGENERATION STOKER BOILER

A. Source Description

The facility includes the construction of a biomass-based steam and electricity generating power plant (CoGen plant) co-located with the enzymatic hydrolysis (EH) ethanol plant. In addition to ethanol production, biomass will be used as a solid fuel in the CoGen plant. The CoGen plant will consist of one (1) steam driven electricity-producing turbine nominally rated up to a total of 22 Megawatts (MW). Electrical power will be supplied exclusively to the facility. Steam will be generated for use in the electricity-producing turbine by one (1) biomass stoker combustion boiler.

The stoker boiler, rated at 500 MMBtu/hr maximum design heat input, burning a combination of wheat straw, milo stubble, corn stover, switchgrass, other opportunity feedstocks that are available, enzymatic hydrolysis residuals (including lignin-rich/lignin-lean stillage cake and thin stillage syrup), particles collected during biomass grinding, NCG vent streams, wastewater treatment sludge and biogas. Natural gas will be used during start-up periods as required per manufacturer recommendations. The emissions from the stoker boiler will be ventilated to the boiler stack (EP-20001) for emissions control.

B. NOx BACT Review

Nitrogen oxides are formed during combustion by two major mechanisms: thermal formation (thermal NOx) and fuel formation (fuel NOx). Thermal NOx results from the high temperature oxidation of nitrogen and oxygen. In this mechanism, nitrogen is supplied from air which is approximately 79% nitrogen by volume. Thermal NOx formation is primarily dependent on combustion temperature. Thermal NOx formation increases exponentially with temperature and becomes significant at temperatures above 2,200°F. Fuel NOx results from the direct oxidization of organic nitrogen in the fuel.

In the case of solid biomass, it is expected that minimal thermal NOx will be created due to the low combustion temperature that will be targeted. Therefore, NOx emissions resulting from the combustion of solid biomass are primarily from fuel nitrogen combustion. The NOx emission factor for the boiler fuel was based on a blended biomass nitrogen content of 1.40 to 1.54% by weight when the boiler is fired predominately by solid fuel, with approximately 11% of the fuel nitrogen converting to NOx. The calculated uncontrolled emission rate based on fuel properties and engineering estimates for N-to-NOx conversion is between 0.70 and 0.76 lb/MMBtu.

1. Identify Available Control Options

   There are two major technology categories for controlling NOx emissions from the biomass-fired boiler: combustion controls and post-combustion controls. Combustion and non-combustion controls may be used together to achieve the lowest emission rates. The following control options have been identified and considered in determining BACT for the biomass-fired stoker boiler when combustion the blended biomass fuel (including natural gas):

   a. Combustion Controls

      i. Boiler Type Selection
      ii. Burner Optimization
      iii. Over-fire Air (OFA)
      iv. Low-NOx Burner
      v. Exhaust or Flue Gas Recirculation (EGR or FGR)

   b. Post Combustion Controls

      i. Selective Catalytic Reduction (SCR);
      ii. Regenerative SCR (RSCR); and
      iii. Selective Non-Catalytic Reduction (SNCR)

   c. Eliminate Technically Infeasible Control Options

      i. Boiler Type Selection

         As part of the DOE funding of this project, ABBK is proposing to construct a state-of-the-art biomass-to-ethanol and biomass-to-energy production facility. The biomass-to-energy facility will combust process residuals from the enzymatic hydrolysis ethanol production process, as well as other process residuals and raw biomass. There is no boiler operating in the U.S. at the scale proposed by ABBK (500 MMBtu/hr, 325,000 pounds per hours 920 psig /750 °F steam, 22 Megawatts of electricity with the proposed fuels. The proposed boiler must be capable of burning a combination of raw biomass (consisting of corn stover, wheat straw, milo (sorghum) stubble, corn stover, switchgrass, and other opportunity feedstocks that are available), enzymatic hydrolysis residuals (including lignin-rich stillage cake and thin stillage syrup), particles collected during biomass grinding, NCG vent streams, wastewater treatment sludge and biogas.

Due to the use of "emerging technology" in the selection of the boiler fuel, ABBK has discussed with both stoker-type boiler vendors and fluidized bed combustion (FBC) boiler vendors and has decided that due to the inherent high alkalinity, the ash content of the fuel, and use of enzymatic hydrolysis residuals consisting of lignin-rich stillage cake and thin stillage syrup as the primary boiler fuel, that the stoker-type boiler poses the lowest overall risk to the success of the project. A thorough review of recently permitted biomass-fired boilers was conducted as part of this BACT analysis and the results support ABBK's selection of a stoker-type boiler. Several recent BACT determinations have been made for stoker-type biomass-fired boilers.

ii. Burner Optimization

Burner optimization is usually the first method used to control NOx formation. Optimization is achieved by modifying boiler-operating conditions. Excess air control, boiler fine tuning and balancing the fuel and air flow to the burner will achieve minimum NOx formation reductions. Reducing excess air in combination with fine tuning the boiler could achieve NOx formation reduction rates from 10% to 20%.

iii. Over-Fire Air (OFA)

In a stoker boiler, when primary combustion uses a fuel-rich mixture, OFA helps to complete the combustion process. Because the mixture is always off-stoichiometric during combustion, the combustion temperature is reduced. After all other stages of combustion, the remainder of the fuel is oxidized in the OFA zone. The biomass-fired boiler will utilize an OFA system to promote vigorous mixing of the combustion gases to maximize combustion efficiency and reduce pollutant emissions. OFA is a combustion staging process that is used to create an oxygen depleted zone where unburned hydrocarbons act to reduce the NOx that is formed near the grate.

iv. Low-NOx Burner

Low-NOx burners control thermal NOx formation by avoiding high temperature combustion zones and uneven oxygen distribution. This is accomplished by burner designs that carefully control the mixing of fuel and combustion air. Generally, use of low-NOx burners requires a wall-fired furnace and pulverized biomass fuel that is burned in suspension with coal or natural gas. Low-NOx burners have not been commercially applied to FBC or stoker boilers. Therefore, low-NOx burner technology is not considered a technically feasible control option for control of NOx from the combustion of the solid biomass. Low-NOx burners can be employed for natural gas firing. These types of burners will be utilized on the biomass-fired boiler for natural gas combustion.

v. Exhaust or Flue Gas Recirculation (EGR or FGR)

Flue gas recirculation for NOx control includes gas recirculation into the furnace or into the burner. In this technology 20% to 30% of the flue gas (at 350-400°C) is re-circulated and mixed with the combustion air. The resulting dilution in the flame decreases the temperature and availability of oxygen therefore reducing thermal NOx formation. Because of the properties of the solid biomass and the boiler furnace (combustion zone) design, FGR cannot be implemented on stoker boilers. Therefore, FGR technology is not considered a technically feasible control option, and is not considered further in this BACT analysis.

vi. Selective Catalytic Reduction (SCR)

SCR systems are typically implemented on stationary fossil fuel combustion units such as electrical utility boilers, industrial boilers, process heaters, gas turbines and reciprocating internal combustion engines. Theoretically, SCR systems can be designed for NOx removal efficiencies up to 100%. Commercial coal-, oil- and natural gas-fired SCR systems are often designed to meet control targets of over 90%. However, maintaining this efficiency is not always practical from a cost standpoint. In practice, SCR systems operate at efficiencies in the range of 70% to 90%.

SCR systems use a nitrogen reducing agent (generally ammonia, NH3) to reduce NOx emissions by injecting NH3 into the exhaust gas upstream of a catalyst. Ammonia absorbed on the catalyst surface selectively reacts with the NOx in the presence of oxygen to form nitrogen (N2) and water. The chemical reactions involved in the SCR process are:

$$NH_3 + NO + (1/4)O_2 \rightarrow N_2 + (3/2)H_2O$$

$$NH_3 + (1/2)NO_2 + (1/4)O_2 \rightarrow (3/2)N_2 + (3/2)H_2O$$

Catalyst performance is optimized when the oxygen level in the exhaust gas stream is above 2% to 3%. Commercial applications of this technology have been demonstrated over an extended temperature range from 300 °F to 1000 °F. The catalyst material that is used defines the optimal temperature range. Heat recovery steam generation (HRSG) is a beneficial part of the facility's boiler system and therefore, inlet temperatures can be reduced from 1300 °F + at the boiler furnace (combustion zone) to the SCR optimum temperature range of 480 °F to 800 °F.

The advantages of an SCR include higher NOx reductions than SNCR. Also SCR reactions occur with a lower and broader temperature range than SNCR, and the SCR does not require modifications to the combustion unit.

Disadvantages of the SCR are higher capital and operating costs than SNCR; large volume of reagent and catalyst required; potential downstream equipment cleaning; and addition of ammonia in waste gas stream and ash. Ammonia in the waste gas stream is an additional environmental concern. Most SCR systems have been installed to reduce NOx emissions in exhaust streams with relatively little particulate matter, like natural gas-fired boilers and turbines.

The proposed boiler will combust a blended biomass fuel that has a calculated ash content of approximately 13%. The estimated ash content of this blended biomass fuel is considerably higher than wood, which has an ash content of approximately 1%; or natural gas, which has a negligible ash content. Further, the blended biomass will pose other significant technical challenges due to the higher levels of sulfur (0.98% by weight); presence of alkaline and alkaline-earth metals such as sodium, potassium and calcium; and high concentrations of hydrochloric acid (HCl).

In a high ash environment, there are four basic mechanisms for deactivation of an SCR catalyst which reduce or eliminate the ability of the SCR system to control NOx emissions: 1) Poisoning; 2) Plugging; 3) Fouling; and 4) Erosion. Poisoning results from a chemical attack on the surface of the catalyst. Plugging involves microscopic blockage of catalyst pores by small ash particles. Fouling involves macroscopic blockage of the catalyst through a build-up of ash. Erosion of the catalyst surface is due to the abrasive nature of the particles in a high dust environment and can lead to deactivation through the wearing away of the catalyst surface.

Tail gas SCR systems are an SCR system where the catalyst is located downstream of the SO_2 and particulate control device to reduce deactivation problems. The higher concentrations of SO_2 will still exacerbate the catalyst deactivation even with the placement of the SCR catalyst downstream of the SO_2 and PM control devices. In a tail gas SCR arrangement, the ammonia injection rate to the SCR must be carefully controlled to prevent excess ammonia, called ammonia slip, from being carried over since there is no pollution control system downstream of the tail gas SCR system.

Catalysts used in SCR systems can be divided into three categories based on the temperature range in which they are designed to operate. High temperature catalysts operate in the 650 to 1,000 °F range, medium temperature in the 500 to 725 °F range, and low temperature in the 300 to 680 °F range.

Low-temperature catalysts, which operate at the expected boiler exhaust temperature, are typically used to reduce NOx emissions in relatively "clean" (i.e., low particulate and low sulfur) exhaust from natural gas combustion sources. While wood is typically not considered a high-sulfur fuel, corn stover is expected to contain higher levels of sulfur (0.98% by weight). Low temperature catalysts readily convert a portion of any SO_2 in the exhaust to SO_3, which then would react with the injected ammonia to produce ammonium sulfate and sulfite, which are highly corrosive salts. Because low temperature catalysts are highly sensitive to SO_3 poisoning, low temperature catalysts are considered not technically feasible.

vii. Regenerative SCR (RSCR)

Medium- and high-temperature catalysts are less prone to complications from sulfur and particulate in the exhaust, but both would require exhaust reheat. Regenerative SCR (RSCR) systems have been developed recently to make application of a medium temperature SCR system more economical by using a regenerative ceramic bed to recover heat from the reheated flue gases to limit the use of the reheat fuel. Also, because reheat fuel is kept to a minimum, it facilitates positioning the NOx reduction system after a dust collection device, which serves to prolong the life of the catalyst. Similar to a tail gas SCR system, in an RSCR arrangement, the ammonia injection rate to the SCR must be carefully controlled to prevent excess ammonia.

Because of the high potential for catalyst deactivation, traditional SCR is not a technically feasible NOx control technology for the biomass-fired boiler. However, based on the recent successful application of tail gas SCR or RSCR to wood-fired boilers, tail gas SCR or RSCR has been proven to be a technically feasible control option for the biomass-fired boiler. The reduction potential with a tail gas SCR or RSCR is approximately 60% to 80% based on BACT determinations contained in the RBLC database.

viii. Selective Non-Catalytic Reduction (SNCR)

SNCR systems are capable of NOx reduction efficiencies in the range of 30% to 75%. SNCR systems are typically installed on a wide range of boiler configurations including: dry bottom wall fired and tangentially fired units; wet bottom units; stokers; and fluidized bed units. These units fire a variety of fuels such as coal, oil, gas, biomass and waste. SNCR systems reduce NOx by injecting NH3 into the process where the NH3 will selectively react with NOx to produce N2 and water. The NOx reduction reaction occurs at temperatures between 1600 °F to 2100 °F. In addition to operating temperature requirements, good mixing and sufficient residence time must be present. As the desired NOx removal efficiency is increased, the amount of ammonia slip increases due to the non-uniform distribution of reacting gases and the stoichiometric ammonia to NOx ratio required to achieve higher reductions.

Issues related to ammonia transport and storage, ammonia slip emissions and the associated increase in PM10 emissions are all considerations when specifying an SNCR control system. For SNCR, ammonia injection nozzles would be positioned in the combustion zone to use the relatively high temperatures there to promote the reaction of NOx and ammonia. The SNCR system can be located inside the furnace because SNCR systems do not rely on a catalyst which is subject to plugging from particulate matter in the flue gases. The relative simplicity and effectiveness of SNCR systems has resulted in SNCR becoming the most common add-on NOx control technology for larger sized solid fuel-fired boilers that operate under steady load; however, the potential for ammonia slip is greater with SNCR. The advantages of an SNCR system are that capital and operating costs are among the lowest of all

NOx reduction methods. Disadvantages of the SNCR are lower NOx reductions than SCR; potential downstream equipment cleaning; and addition of ammonia in waste gas stream and ash.

2. Rank Technically Feasible Control Options

The biomass-fired boiler control technologies and emission control efficiencies are:

Control Technology	SO_2 Reduction Efficiency
Tail Gas SCR or RSCR	60% to 80%
SNCR	30% to 50%
Combustion Controls/OFA/ Burner Optimization	10%-20%

Based on previous discussion, the top performing technically feasible NOx control technology identified for further evaluation as part of this BACT analysis is the Tail Gas SCR or RSCR system.

3. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify technologies used to control NOx emissions from similar sized biomass-fired boilers. The biomass-fired boilers with heat inputs greater than 250 MMBtu/hr were listed on the RBLC database with a wide range of NOx control as BACT, including no control, combustion control, SCR and SNCR. The BACT emission rates range from 0.07 to 0.31 lb/MMBtu (based on either 24-hour or 30-day rolling averages). No facilities in the RBLC database burn the same types of fuels as ABBK. Most biomass boilers in the database burn various types of wood waste in conjunction with other fuels, including coal, natural gas, fuel oil, wastewater sludge, tire-derived fuel, railroad ties and other non-municipal wastes or production by-products.

4. Establish BACT

The use of a tail gas SCR is the top performing NOx emission control for the biomass-fired stoker boiler and is selected BACT. The tail gas SCR system would reduce NOx emissions by 992 tons per year (from 1,653 to 661 tons per year). Based on best engineering estimates, the proposed biomass-fired stoker boiler with tail gas SCR control will achieve a NOx emission rate of 0.30 lb/MMBtu for the maximum emission case fuel blend (or 60 % reduction). Therefore, a BACT limit of 0.30 lb/MMBtu including periods of startup, shutdown, or malfunction (SSM) and 150 pounds per hour on a 1-hour average, including periods of startup, shutdown, or malfunction are proposed as BACT for the maximum emission case fuel blend and the nominal typical emission case fuel blend.

Table B-2. Biomass-Fired Stoker Boiler (EP-20001) NOx Proposed BACT Limits

Fuel Blend Nitrogen Content	NOx Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
Maximum emission case fuel blend	0.30 lb/MMBtu (30-day rolling avg. including SSM)	SCR with OFA and Good Combustion Practices (GCP)
Maximum emission case fuel blend	150 lb/hr (1-hour avg. including Startup and Shutdown; Excluding Malfunction)	

5. BACT Compliance

The nitrogen compound-based control technologies, like SCR, may have a collateral environmental impact on the stoker boiler. The release of unreacted nitrogen compounds could potentially result in a visible plume from the boiler(s). SCR, for instance, invariably involves emissions of unreacted ammonia, called ammonia slip. The escaping ammonia can react with sulfur and chloride compounds in the flue gas to form fine particulate matter and, potentially, a visible plume. These particles are formed at lower temperatures that exist downstream from the particulate control device and are not typically captured. The ammonia slip represents the emission of a toxic air pollutant.

Additionally, much of the chloride contained in the biomass is emitted as HCl gas when the biomass is combusted. The fact that potentially high HCl concentrations in the boiler(s) flue gases exist, indicates that there is also a potential for producing ammonium chloride fume when nitrogen compounds such as ammonia are added to the flue gas as part of using SNCR, SCR, or RSCR controls. Acid gases, like HCl, can degrade the alumina catalyst supports that are normally used for RSCR.

C. SO_2 BACT Review

Emissions of sulfur oxides from boilers result from the oxidation of sulfur present in the fuel. Sulfur oxides formed during combustion are primarily SO_2, with minor amounts of SO_3 and gaseous sulfates. These sulfur compounds form as the sulfur contained in the fuel is oxidized during the combustion process. Uncontrolled sulfur oxide emissions from biomass-fired boilers vary directly with the sulfur content.

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

a. Wet Flue Gas Desulfurization (FGD); and

b. Dry Flue Gas Desulfurization (FGD)

2. Eliminate Technically Infeasible Control Options

"Scrubber" is a general term that describes an air pollution control device or system that use absorption, both physical and chemical, to remove pollutants from the process gas stream. Scrubber systems rely on a chemical reaction with a sorbent to remove a wide range of pollutants, including acid gases, SO_2, fine particulates and heavy metals (i.e., mercury) from flue gases. When used to remove or "scrub" SO_2 from the flue gas, these devices are commonly called FGD systems. FGD systems are generally classified as either "wet" or "dry". Wet scrubbers have been applied on combustion units firing coal and oil ranging in size from 50 MMBtu/hr to 15,000 MMBtu/hr. Dry and spray dryer scrubbers are generally applied to units less than 3,000 MMBtu/hr.

In a wet FGD system, liquid sorbent slurry is sprayed into the flue gas in an absorber vessel or spray tower. The gas phase or particulate pollutant comes into direct contact with the sorbent liquid and is dissolved or diffused (scrubbed) into the liquid. The liquid interface for gas and particle absorption includes liquid sheets, wetted walls, bubbles and droplets. In the wet processes, a wet slurry waste or by-product is produced. Spent slurry from the reaction is generally disposed of, or when oxidized, results in a gypsum by-product that can be sold. Most wet FGD systems use alkaline slurries of limestone or slaked lime as sorbents; however, sodium-based reagents (sodium bicarbonate or naturally occurring sodium carbonate/sodium bicarbonate minerals, like Trona (trisodium hydrogendicarbonate dehydrate)) are also used. Sulfur oxides react with the sorbent to form solid salts.

Scrubber technologies for wet scrubbing of gaseous pollutants can achieve extremely high levels of multi-pollutant control from utility and industrial coal-fired boilers, waste-to-energy systems, and other industrial processes. New wet scrubbers routinely achieve SO_2 removal efficiencies of 90% to 95%, with some scrubbers achieving removal efficiencies of up to 98%.

In a dry FGD process, particles of an alkaline sorbent are injected into a flue gas, producing a dry solid by-product. In dry FGD scrubbing, the flue gas leaving the absorber is not saturated (the major distinction between wet and dry scrubbers). Dry scrubbers systems can be grouped into two categories: spray dryers and dry injection systems.

A spray dryer (or semi-dry scrubber) uses much smaller amounts of liquid than a wet FGD system. With a spray dryer absorber system, the flue gases enter an absorbing tower (dryer) where hot gases are contacted with finely atomized slurry. Various calcium and sodium-based reagents can be utilized as the sorbent. SO_2 is absorbed by the sorbent slurry mixture and react to form solid salts. The heat of the flue gas evaporates the water droplets in the sprayed slurry, and a non-saturated flue gas exits the absorber tower where it is then routed to a particulate control device such as an ESP or fabric filter. The waste product can be disposed of, sold as a by-product or recycled to the slurry. Spray dryers commonly are designed for SO_2 removal efficiencies of 80% to 90%.

Dry injection systems involve the injection of a dry sorbent (normally lime or limestone) into the flue gas in the upper reaches of the boiler, or in the ductwork following the boiler. Sulfur oxides react directly with the dry sorbent, which are collected in a downstream particulate control device. Dry scrubbers have significantly lower capital and annual costs than wet systems because they are simpler, demand less water and waste disposal is less complex. Newer applications of dry sorbent injection on small coal-fired industrial boilers have achieved greater than 90% SO_2 control efficiencies.

Scrubbers have been used in the EPA Acid Rain Program on coal-fired boilers, which are significant sources of hydrochloric acid (HCl) and hydrofluoric acid (HF). According to the EPA and others, both wet and dry scrubbers have been shown to reduce HCl emissions by 95% and more, and wet scrubbers have been shown to reduce HF emissions by more than one-third. In addition, wet scrubbers also provide significant removal of arsenic, beryllium, cadmium, chromium, lead, manganese, and mercury from flue gas.

3. Rank Technically Feasible Control Options

Control Technology	SO_2 Reduction Efficiency
Wet FGD	90% to 95%
Dry FGD	80% to 90%

The top performing control technology for SO_2 control is wet FGD. The highest removal efficiencies are achieved by wet scrubbers, greater than 90%, and the lowest by dry scrubbers, typically 80%. However, newer dry scrubber designs are capable of higher control efficiencies, on the order of 90%. Because of the additional acid gases and air toxics to be controlled in the boiler exhaust, a dry FGD system is preferred. A wet FGD is generally applied units larger than the proposed biomass-fired boiler, and offer no significant benefit over dry FGD; therefore, no further analysis will be performed for a wet FGD system. The addition of a baghouse following the dry scrubber system improves SO_2 and chloride capture (estimated to be 90% and 95%, respectively) as it provides additional residence time. The partially reacted sorbent sticks to the filter and builds a layer to capture additional pollutants. These emissions of concern are discussed in more detail in the previous section of this BACT analysis, *Environmental Concerns*.

Based on the above discussion, the top performing technically feasible SO_2 control identified for further evaluation as part of this BACT analysis is a dry (sorbent injection) scrubber system.

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify technologies used to control SO_2 emissions from similar sized biomass-fired boilers. The biomass-fired boilers with heat inputs greater than 250 MMBtu/hr were listed on the RBLC database with SO_2 BACT limits between 0.012 and 1.54 lb/MMBtu. No facilities in the RBLC database burn the same types of fuels as ABBK. Most biomass boilers in the database burn various types of wood/wood waste in conjunction with other fuels, including coal, natural gas, fuel oil, wastewater sludge, tire-derived fuel, railroad ties and other non-municipal wastes or production by-products. The lowest SO_2 emission rate in the RBLC database is for Schiller Station (0.02 lb/MMBtu). Schiller Station uses a fabric filter with a spray dryer (lime injection) scrubber system to control particulates, SO_2, sulfuric acid mist and HCl.

5. Establish BACT

Based on best engineering estimates, the proposed BFB boilers with a dry (sorbent injection) scrubber system can consistently achieve an SO_2 emission rate of 0.21 lb/MMBtu (or 92% SO_2 reduction).

Therefore, a BACT limit of 0.21 lb/MMBtu including periods of startup, shutdown, or malfunction and 106.16 pounds per hour on a 1-hour average, excluding periods of startup, shutdown, or malfunction are proposed as BACT for the maximum emission case fuel blend.

The biomass-fired boiler proposed SO_2 BACT limits are listed in Table B-3.

Table B-3. Biomass-Fired Stoker Boiler (EP-20001) SO_2 Proposed BACT Limits

Fuel Blend Sulfur Content	SO_2 Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
Maximum emission case fuel blend	0.21 lb/MMBtu (30 day rolling average including SSM)	Injection of sorbent (lime) in combination with a dry flue gas desulfurization (FGD) system
Maximum emission case fuel blend	106.16 lb/hr (1-hour avg. including Startup and Shutdown; Excluding Malfunction)	

The pound per hour limit shall be considered BACT for the maximum 1-hour limit to ensure compliance with the 1-hour National Ambient Air Quality Standard (NAAQS). The proposed 1-hour BACT limit in pounds per hour would apply during all times, including during start-up and planned shutdown and excluding malfunctions. The proposed BACT limit in lb/MMBtu would apply at all times, including during start-up, shutdown and malfunctions, and is based on a 30-day rolling average compliance period.

During start-up, SO_2 is minimized through the use of low sulfur fuels (i.e., natural gas) and/or the injection of a sorbent into the furnace because the FGD system does not work at optimum design until approximately 4 hours after start-up.

D. CO BACT Review

Fuel combustion CO emissions result from the incomplete combustion of carbon and organic compounds contained in the fuel. Factors affecting CO emissions include firing temperatures, excess oxygen and residence time in the combustion zone, and combustion area mixing characteristics. An increase in combustion zone residence time and oxygen levels and improved mixing of fuel and combustion air will increase oxidation rates and decrease CO emission rates. The proposed biomass stoker boiler is designed and operated to minimize the formation of CO by maximizing the combustion area mixing of the biomass fuel and combustion air.

In general, emissions of NOx and CO are inversely related (i.e., decreasing NOx emissions will result in an increase in CO emissions and vice-versa). Accordingly, boiler combustion controls designed to lower NOx emissions (e.g., lower combustion temperatures) would also be expected to cause a collateral increase in CO emissions. Accordingly, boiler combustion design and operation requires a balancing of the competing goals to minimize the formation of both NOx and CO.

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Good Combustion Practices (GCP); and

   b. Oxidation Catalysts

2. Eliminate Technically Infeasible Control Options

   Optimization of the design, operation, and maintenance of the boiler combustion system is the primary technology available for reducing CO emissions. Good combustion controls involve boiler combustion designs and operating practices that improve the oxidation process and minimize incomplete combustion. Key combustion design and operating parameters include sufficient excess air, high combustion temperatures, adequate residence time, and good mixing of the combustion air and fuel.

   Oxidation catalysts have recently been used to reduce CO emissions as a post combustion control system on gas-fired combustion turbines, but not on biomass-fired boilers. Acceptable catalyst operating temperatures range from 400°F to 1,250°F, with the optimum temperature range being 850°F to 1,100°F. Below 600°F, a greater catalyst volume would be required to achieve the same reduction.

   The boiler's exhaust temperatures will be below 400°F and flue gas temperatures in the furnace are greater than 1,250°F. As a result, a suitable location within the boiler would have to be created in order to provide the proper temperature range and residence time for installation of an oxidation catalyst. Such a location does not exist in the current solid biomass-fired boiler configuration design.

   Further, implementation of oxidation catalysts involves a complex technology transfer project that has not been commercially demonstrated on biomass-fired boilers. A catalytic oxidizer offers no performance advantages over the top performing technology, thermal oxidation in the furnace due to good combustion practices. Also, oxidation catalysts are susceptible to deactivation due to impurities present in the exhaust gas stream. Arsenic, iron, sodium, phosphorous, and silica will all act as catalyst poisons causing a reduction in catalyst activity and pollutant removal efficiencies. Oxidation catalysts are also subject to masking and/or binding by fly ash contained in the exhaust stream of a boiler. Given these facts, it was determined unnecessary to evaluate the cost of unproven and potentially infeasible technology that is clearly more expensive than the top performing technology selected for this application.

3. Rank Technically Feasible Control Options

   Based on the above discussion, the technically feasible CO controls identified for further evaluation as part of this BACT analysis is GCP.

4. Evaluate Technically Feasible Control Options

   EPA's RBLC database was reviewed to identify technologies used to control CO emissions from similar sized biomass-fired boilers. The biomass-fired boilers with heat inputs greater than 250 MMBtu/hr were listed on the RBLC database with CO BACT limits between 0.075 and 0.63 lb/MMBtu. No facilities in the RBLC database burn the same types of fuels as ABBK. Most biomass boilers in the database burn various types of wood/wood waste in conjunction with other fuels, including coal, natural gas, fuel oil, wastewater sludge, tire-derived fuel, railroad ties and other non-municipal wastes or production by-products. GCP is the primary control technology that has been applied for the control of CO emissions from similar sized biomass-fired boilers.

   Considering the differences in the fuel nitrogen content of wet wood verses the blended biomass fuel at ABBK (estimated to be 0.22% by weight versus 1.54% by weight), it is reasonable to expect the ABBK boiler's CO emissions will be greater. The design of the boiler will be intended to simultaneously minimize the formation of both NOx and CO emissions; therefore, the design features that minimize CO emissions are interrelated with the boiler optimization used to minimize NOx formation. The implementation of a GCP control will achieve a maximum CO emission rate of at the facility of 0.22 lb/MMBtu.

5. Establish BACT

   Based on best engineering estimates, the proposed biomass-fired boiler with GCP will achieve a CO emission rate of 0.22 lb/MMBtu. Therefore, a BACT limit of 0.22 lb/MMBtu is proposed as BACT.

   The biomass-fired boiler proposed CO BACT limits are listed in Table B-4.

Table B-4. Biomass-Fired Stoker Boiler (EP-20001) CO Proposed BACT Limits

CO Emission Rate	CO Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
110.04 lb/hr	260 ppmv @3%O_2 0.22 lb/MMBtu	Good Combustion Practices (GCP)

The proposed BACT limit in pounds per hour applies during all times, including during SSM, and is based on a 30-day average compliance period.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Fabric Filter Baghouse;

   b. Wet Electrostatic Precipitators (ESPs); and

   c. Dry ESPs.

2. Eliminate Technically Infeasible Control Options

   Fabric filtration in a baghouse consists of a number of filtering bags that are suspended in a housing. Particulate laden gases pass through the housing and collect on the fabric of the filter bag. Fabric filters are generally considered unacceptable for the control of biomass combustion due to the danger of fires unless there is some acid gas control preceding the fabric filter. Because acid gas control in the form of a dry (sorbent injection) scrubber will be utilized, fabric filtration is technically feasible. However, fabric filtration is not technically feasible for condensable particulate matter that is in a vapor form at stack conditions, and thus is not intercepted by the fabric.

   ESPs remove particulate matter from the flue gas stream using the principle of electrostatic attraction. Particulate matter is charged with a high direct current voltage and subsequently attracted to oppositely charge collection plates. Wet ESPs operate using the same principles as standard ESPs, but the final cleaning step of the collection plates utilizes water. Wet and dry ESP systems are technically feasible for the proposed boiler system. However, ESPs are not technically feasible for condensable particulate matter that is in a vapor form at stack conditions, and thus not significantly affected by the electric current.

3. Rank Technically Feasible Control Options

Control Technology	Reduction Efficiency
Baghouse	99+%
Dry ESP	99+%
Wet ESP	99+%

   A baghouse, dry ESP and wet ESP are all capable of achieving filterable $PM/PM_{10}/PM_{2.5}$ emissions reductions of 99% or more. A fabric filter baghouse is preferred for the biomass stoker boiler as the addition of a baghouse following the dry (sorbent injection) scrubber system improves SO_2 and chloride capture (estimated to be 90% and 95%, respectively) as it provides additional residence time. The partially reacted sorbent sticks to the filter and builds a layer to capture additional pollutants.

Further, a wet or dry ESP offer no performance or cost advantages over a baghouse; therefore, no further analysis will be performed for ESPs. The top performing technically feasible $PM/PM_{10}/PM_{2.5}$ control technology identified for further evaluation as part of this BACT analysis is a fabric filter baghouse.

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify technologies used to control $PM/PM_{10}/PM_{2.5}$ emissions from similar sized biomass-fired boilers. The biomass-fired boilers with heat inputs greater than 250 MMBtu/hr were listed on the RBLC database with PM/PM_{10} BACT limits between 0.0064 and 0.15 lb/MMBtu. Fabric filter baghouse, ESP and cyclone control technologies have been applied for the control of PM/PM_{10} emissions from similar sized biomass-fired boilers.
The implementation of a baghouse will achieve a maximum filterable $PM/PM_{10}/PM_{2.5}$ emission rate of at the facility of 0.013 lb/MMBtu. This emission rate is consistent with other established BACT limits for wood-fired boilers, as detailed in the RBLC database review.

The overall filterable PM/PM_{10} control will be based on a 99.8% control efficiency due to the dual control technology design for HCl control. Further, ESPs offers no performance advantages over the top performing technology (baghouse). Given these facts, it was determined unnecessary to evaluate the cost of unproven and potentially infeasible technologies that are clearly more expensive than the top performing technology selected for this application.

5. Establish BACT

The implementation of a fabric filter baghouse will achieve a filterable $PM/PM_{10}/PM_{2.5}$ control efficiency of 99+%. Based on best engineering estimates, the proposed biomass-fired boiler with a baghouse can consistently achieve a filterable PM emission rate of 0.015 lb/MMBtu; a filterable PM_{10} emission rate of 0.013 lb/MMBtu; and a filterable $PM_{2.5}$ emission rate of 0.011 lb/MMBtu.

Table B-5. Biomass-Fired Stoker Boiler (EP-20001)

Filterable PM Proposed BACT Limits

	Filterable PM Emission Rate (lb/hr)	**Filterable PM Proposed BACT Emission Limit(s) (lb/MMBtu)**	**BACT Device(s) or Operational Limitation(s)**
PM	7.27	0.015	Fabric Filter Baghouse
PM_{10}	6.49	0.013	
$PM_{2.5}$	5.58	0.011	

The proposed BACT limit in pounds per hour applies during all times, including during SSM, and is based on a 30-day average compliance period.

II. BACT ANALYSIS OF COOLING WATER TOWER

A. Source Description

The production process will be cooled by circulating water through heat exchangers, a chiller, and the cooling water tower. The cooling tower is an essential utility in the ethanol production and refining process. At the cogeneration plant, exhaust steam is condensed under vacuum against cooling water in the cooling water tower. Enzymatic hydrolysis process steam is extracted from the turbines at a lower pressure from uncontrolled extraction ports. Boiler feedwater preheated steam is also extracted from the turbines from uncontrolled extraction ports. The cooling water tower (EP-04001) will contain three (3) cells, with a total water circulation rate of 43,200 gallons per minute. The cooling water tower will be equipped with a drift (mist) eliminator.

Cooling towers are a source of particulate matter emissions due to the loss or drift of droplets of cooling water containing dissolved solids from the tower. The particulate emissions are assumed all condensable, and therefore all assumed to be less than 1.0 micrometer in diameter. The water generated from the cooling towers will not come into contact with the production processes, thus no VOC emissions are expected.

B. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Drift Eliminators;

   b. Total Dissolved Solids (TDS) Limit;

   c. Total Dissolved Solids (TDS) Removal System; and

   d. Combination of these control options.

2. Eliminate Technically Infeasible Control Options

   Drift elimination is the removal of entrained liquid droplets from a vapor stream. The installation of high efficiency drift eliminators and the use of water treatment technology to further reduce TDS in the cooling water are considered feasible control technologies. The only feasible TDS removal technology identified was demineralization using softeners and ion exchange beds to remove additional TDS from the cooling water makeup stream. Both reverse osmosis and distillation are rejected as TDS reducing options due to their high energy requirements and high annual operating costs relative to ion exchange based on demineralization. Demineralization is not considered technically feasible and was not evaluated in this analysis, as the substantial additional cost of treating and/or disposing of by-product sludge, spent resin and wastewater generated by the demineralization process are cost prohibitive and this technology has not been implemented at similar facilities.

3. Rank Technically Feasible Control Options

   The use of a drift eliminator is the most technically feasible control technology. A TDS limit for the circulating water is usually viewed as a measure that benefits air quality by reducing the dissolved salts that can be precipitated from drift aerosols. To reduce TDS, the facility must introduce a higher volume flow of make-up water to the tower. This has the potential disadvantage of increasing the overall plant water requirements.

4. Evaluate Technically Feasible Control Options

   EPA's RBLC database was reviewed to identify $PM/PM_{10}/PM_{2.5}$ control technologies that were potentially applicable to cooling tower, including a review of cooling towers located at similar facilities and cooling towers permitted within the last year.

   According to EPA's RBLC database, the use of a mist eliminator designed for a 0.0005% drift with TDS limit is ranked as the top control and has been established as BACT technology for cooling towers. Mist eliminators designed for drift loss factors ranging from 0.005% to 0.0005% have been established as BACT at similar facilities and for cooling towers permitted within the last year.

5. Establish BACT

   ABBK proposes the use of the top performing control technology, drift eliminators, to control $PM/PM_{10}/PM_{2.5}$ emissions from the cooling water towers. ABBK also proposes the use of a TDS concentration limit, which is a measurable limit that will be used to demonstrate compliance. The TDS concentration to be used for compliance will be based on a 24-hour average concentration.

Table B-6. Cooling Water Tower (EP-04001) $PM/PM_{10}/PM_{2.5}$ Proposed BACT Limits

	Emission Rate lb/hr	**$PM/PM_{10}/PM_{2.5}$ Proposed BACT Emission Limit ppm TDS**	**BACT Device(s) or Operational Limitation**
PM	0.17	1,575	Drift Eliminator with 0.0005% Drift Rate
PM_{10}	0.12		
$PM_{2.5}$	0.07		

III. BACT ANALYSIS OF FUGITIVE EMISSIONS ASSOCIATED WITH BIOMASS HANDLING PRIOR TO THE GRINDING/MILLING OPERATIONS

A. Source Description

The biomass (e.g., agricultural residues and energy crops) handling operations such as receiving, loading and unloading are sources of fugitive $PM/PM_{10}/PM_{2.5}$ (EP-11110FUG). Biomass will be delivered in bale form primarily on flatbed / module / custom trucks. The baled biomass will either be unloaded directly onto conveyors supplying the grinding lines or unloaded at the biomass overnight staging area or biomass storage field.

The particulate emissions generated from the unloading of material from the trucks and the loading of the material into roll-off dumpsters were assumed equivalent to the particulate emissions generated by the drop operation for aggregate handling and storage piles, as calculated in AP-42, Section 13.2.1, *Aggregate Handling and Storage Piles*, November 2006. The bound agricultural residues and energy crops will typically not be a source of suspended $PM/PM_{10}/PM_{2.5}$ emissions until grinded; however, for the purposes of the receiving PTE calculations, worst-case fugitive emissions were estimated using AP-42 Section 13.2.1.

B. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems; and,

   b. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

      i. Fabric Filter Baghouse;
      ii. Wet Electrostatic Precipitators (ESPs);
      iii. Dry ESPs;
      iv. Venturi Scrubbers; or
      v. Cyclones.

2. Eliminate Technically Infeasible Control Options

   All of the available control options listed above, except the use of dry ESP, are technically feasible for controlling the fugitive $PM/PM_{10}/PM_{2.5}$. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Thus, use of dry ESP is eliminated in this BACT analysis.

3. Rank Technically Feasible Control Options

The reduction in emissions from the decrease in wind velocity due to an enclosure is expected to be up to 100% when compared to processes in the open. A baghouse, wet ESP and Venturi scrubber are all capable of achieving additional emissions reductions of 99% or more. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency (Table B.3-1); and a wet ESP or Venturi scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste.

Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology.

Control Technology	Reduction Efficiency
Partial or Total Enclosure	50% to 99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the biomass receiving operations. There were no emission units identified in the RBLC database that were similar to the agricultural residues and energy crops receiving operations.

This BACT analysis will first review the cost effectiveness of total and partial enclosure of the receiving area. If partial or total enclosure of the receiving areas is determined to be economically viable, the coupling of the enclosures with a dust collection/ventilation system will then be evaluated.

The estimated emissions from biomass receiving operations are summarized in Table B-7 along with the resulting emissions when controlled by total enclosure and partial enclosure compared with the baseline (no control at all).

Table B-7. Biomass Receiving Operations PM/PM_{10} Uncontrolled and BACT Emission Rates

Emission Point No.	Emission Source	Baseline (0% Control Efficiency)	Total Enclosure (99% Control Efficiency)	Partial Enclosure (50% Control Efficiency)	Emission Reductions
		(ton/yr)	(ton/yr)	(ton/yr)	(ton/yr)
EP-11110FUG	Crop Residues Receiving via Truck	PM: 0.16 PM_{10}: 0.075	0.00	PM: 0.08 PM_{10}: 0.037	PM: 0.08 to 0.16 PM_{10}: 0.037 to 0.075

a. Energy Impacts

Use of an enclosure will result in additional electricity required for ventilation.

b. Environmental Impacts

There are no negative environmental impacts associated with the construction of an enclosure, except for the consumption of building materials that otherwise would not be used.

c. Economic Impacts

Table B-8 presents the capital and annual costs associated with the construction of an enclosure for the agricultural residues and energy crops receiving system (EP-11002FUG). Preliminary capital costs were provided by ABBK. Annual costs were estimated using standard engineering estimating practices presented in Section 2, *Generic Equipment and Devices,* of the EPA Air Pollution Control Cost Manual, Sixth Edition, EPA-425/B-02-001.

Table B-8. Agricultural Residues and Energy Crops Receiving Operations Capital and Annual Cost Summary

Description of Cost	Cost in US Dollars[1]	Comments	Notes
TOTAL CAPITAL INVESTMENT (TCI)	$700,000		Note 2
ANNUAL INDIRECT COSTS (IC)			
Administrative Charges	$14,000	2% of TCI	Note 3
Property Taxes	$7,000	1% of TCI	Note 3
Insurance	$7,000	1% of TCI	Note 3
Capital Recovery	$56,400	CRF x TCI	Note 5
TOTAL ANNUAL IC	$84,400		
ANNUALIZED COSTS FOR TOTAL ENCLOSURE	$84,400		
ANNUALIZED COSTS FOR PARTIAL ENCLOSURE	$56,300		Note 6

Note 1: Rounded to nearest $100.

Note 2: Capital costs provided by ABBK

Note 3: Annual operating costs are minimal and consist of minor expenses such as painting and architectural repairs, as well as the cost of operating the enclosure's ventilation system. These direct costs have not been included in the cost analysis of the enclosure.

Note 4: Overhead is not considered because it is based on the sum of operating, supervisory, and maintenance labor and material costs, which are assumed negligible for the enclosure.

Note 5: The capital recovery cost factor (CRF) is a function of the building life (typically 30 years) and the opportunity cost of the capital (i.e., interest rate). The capital recovery factor is calculated as follows:

$CRF = [\, i\,(1 + i\,)^n\,] \,/\, [(1 + i)^n - 1]$

Where: CRF = capital recovery factor
i = annual interest rate (fraction)
n = number of payment years
A 30-year equipment life and a 7% interest rate CRF = 0.0806.

Note 6: Partial enclosure costs estimated to be $^2/_3$ total enclosure costs.

Table B-9 summarizes the PM/PM_{10} BACT analysis results for agricultural residues and energy crops residues receiving (EP-11110FUG). The baseline emission rates used for calculating costs are based on no controls. The table shows that additional PM/PM_{10} reductions could be provided by the use of an enclosure for each system.

The annualized cost for an enclosure is calculated as the sum of the annual costs, plus a capital recovery factor multiplied by the total capital investment costs. The total annualized cost to achieve either 50% or 99% control of the PM/PM_{10} from the agricultural residues and energy crops receiving system is estimated to be $56,300 or $84,400, respectively.

Table B-9. Agricultural Residues and Energy Crops Receiving Operations PM/PM10 BACT Analysis Results

Control Option	Emission Reduction (ton/yr)[1]	Annualized Costs ($/yr)	Cost Effectiveness ($/ton)	Energy Impacts[2]	Environmental Impacts[3]
None	N/A	Baseline	N/A	Baseline	Baseline
Total Enclosure	PM: 0.16 PM_{10}: 0.075	$84,400	PM: $0.53MM PM_{10}: $1.13MM	Negligible	Negligible
Partial Enclosure	PM: 0.08 PM_{10}: 0.037	$56,300	PM: $0.70MM PM_{10}: $1.52MM	Negligible	Negligible

Note 1: PM emissions reductions estimated using a baseline PM emission rate of 0.16 ton/yr and 99% control efficiency for total enclosure, or 50% control efficiency for partial enclosure. PM_{10} emissions reductions estimated using a baseline PM_{10} emission rate of 0.075 ton/yr and 99% control efficiency for total enclosure, or 50% control efficiency for partial enclosure.

Note 2: Energy impacts were assumed negligible; however, electricity will be required to operate the ventilation and baghouse systems, if installed.

Note 3: Environmental impacts were assumed negligible; however, building materials will be required for the construction of the enclosure.

Based on the lowest cost effectiveness of over $0.53MM per ton of PM removed and over $1.13MM per ton of PM_{10} removed, the PM/PM_{10} reductions for emissions from Crop Residues Receiving via Truck (EP-11110FUG) come at a substantial cost in terms of economic impacts. Therefore, ABBK concludes that the PM/PM_{10} emissions reductions that could be attained with enclosures for agricultural residues and energy crops receiving are not justified by the cost of control associated with this technology.

5. Establish BACT

The proposed BACT is good work practices with no additional controls.

6. BACT Compliance

A Fugitive Dust Control Plan will be developed and will detail the work practices to be implemented to reduce fugitive emissions from agricultural residues and energy crops receiving and processing operations. Further, opacity from this source is limited to 20% by K.A.R. 28-19-650. The Fugitive Dust Control Plan will address this source to ensure compliance with the K.A.R. standard. ABBK will also provide a copy of the Fugitive Dust Control Plan and associated documentation to KDHE upon request to demonstrate compliance with BACT.

IV. BACT ANALYSIS OF GRINDING/MILLING, HANDLING, AND STORAGE OPERATIONS OF BIOMASS MATERIALS PRIOR TO USE AS FEEDSTOCK IN ETHANOL PRODUCTION PLANT AND AS BIOMASS FUEL IN THE COGENERATION PLANT

A. Source Description

The biomass (e.g., agricultural residues and energy crops) grinding/milling, handling and storage operations are a source of $PM/PM_{10}/PM_{2.5}$ emissions which are emitted as point source emissions. The bound biomass bales will typically not be a source of suspended $PM/PM_{10}/PM_{2.5}$ emissions until grinded; therefore, no emissions are estimated from the baled biomass stored in the temporary biomass staging area or biomass storage field.

Generally, the entire biomass grinding/milling, handling, and storage operations begins at the process infeed conveyor line. Once the retrieved bales are delivered to the process infeed conveyor line, the biomass grinding, handling and storage system will be a closed system designed with high velocity pickup of particles; therefore, a capture efficiency of 100% is anticipated throughout the system. The biomass grinding/milling and handling systems will aspirate to fabric filter dust collectors (baghouses) for control of particulate emissions. Building openings and ventilation will be kept to a minimum consistent with required operations and good industry safety and health practices.

B. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems;

   b. Pneumatic conveying of materials through pipes and duct work; and,

   c. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

      i. Fabric Filter Baghouse;
      ii. Wet ESPs;
      iii. Dry ESPs;
      iv. Venturi Scrubbers; or
      v. Cyclones.

2. Eliminate Technically Infeasible Control Options

   Enclosures reduce particulate emissions by containing the material and preventing release of particulates or by reducing the wind that can entrain small exposed particles. Enclosures are typically used to capture emissions from operations like grinding and material transferring/handling so that the dust emitted can be collected and vented to a control device.

   Types of enclosures typically used for handling dry solids are buildings, silos, hoppers, bins and conveyor covers. In the case of building enclosures, the degree of control is proportional to the degree to which the operation is enclosed. However, in well designed systems, these types of enclosures are totally enclosed.

   Solid transfer operations include gravity and pneumatic flow, conveying on belts, front-end loaders and buckets. Pneumatic flow is always enclosed in pipes. All the other types of transfer operations can be conducted with or without enclosure.

   Due to health and safety reasons, most enclosed operations require ventilation to remove the particulates generated by the operations. Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures, or pipes and duct work, is the fabric filter baghouse. A baghouse has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air.

   Other control devices, such as ESPs, induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Wet ESPs, Venturi scrubbers and cyclones are considered technically feasible for use in the receiving operations.

3. Rank Technically Feasible Control Options

   A baghouse, wet ESP and Venturi scrubber are all capable of achieving emissions reductions of 99% or more when employed with an enclosure or pipes and duct work. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency (Table B.4-1); and a wet ESP or Venturi scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste. Venturi scrubbers will be utilized in the process design for control of PM when the collected PM can be recovered and either reintroduced into the process stream for further processing, or when the collected PM is viewed as trash (i.e., dirt or other material that will interfere with production). Systems equipped with Venturi scrubbers will also be designed with baghouse control; therefore, the baghouse is the final dust control system of the exhaust stream.

   Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology. Enclosures, piping and duct work must be maintained under negative pressure to achieve maximum control.

Negative pressure is created by exhausting air, which is subsequently controlled by a baghouse.

Control Technology	Reduction Efficiency
Enclosure	50% to 99+%
Pipes and Duct Work	99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the agricultural residues and energy crops grinding and handling operations.

The most effective, technically feasible option identified for control of the emissions from the agricultural residues and energy crops grinding and handling operations is the use of a baghouse. This is the top performing control technology.

5. Establish BACT

Based on the review of EPA's RBLC, recent PM/PM_{10} BACT limits range from 0.004 to 0.005 grains per dry standard cubic foot (gr/dscf).

In all of the RBLC cases, the BACT limits for these sources are based on the use of a baghouse to control the grinding/hammermilling and handling PM/PM_{10} emissions. The use of an enclosed system equipped with a baghouse is technically feasible and will be employed. Table B-10 lists the $PM/PM_{10}/PM_{2.5}$ proposed BACT limits. The $PM_{2.5}$ emission limits are based on the estimated weight fraction used to estimate potential emissions (17% by weight $PM_{2.5}$).

6. BACT Compliance

ABBK proposes to meet the agricultural residues and energy crops grinding and handling operations PM/PM_{10} BACT limit based on the average of at least three test runs conducted at each baghouse, and a visible emissions limit of 0% opacity.

Table B-10. Agricultural Residues and Energy Crops Grinding and Handling Operations $PM/PM_{10}/PM_{2.5}$ Proposed BACT Limits

Stack ID	Equipment/ Process	Material Processed	Pollutant	Emission Rate (lb/hr)	Proposed BACT Emission Limit(s) gr/dscf	BACT Device(s) or Operational Limitation(s)
EP-11120	Floor Sweep System DC	Agricultural Residues and Energy Crops	PM/PM_{10} $PM_{2.5}$	0.27 0.05	0.004 0.0007	Fabric Filter Baghouse
EP-11110	Bale Grinder DC	Agricultural Residues and Energy Crops	PM/PM_{10} $PM_{2.5}$	4.93 0.84	0.004 0.0007	Fabric Filter Baghouse
EP-11170	Classifier Cyclone # 1 DC	Agricultural Residues and Energy Crops	PM/PM_{10} $PM_{2.5}$	0.74 0.13	0.004 0.0007	Fabric Filter Baghouse
EP-11270	Classifier Cyclone # 2 DC	Agricultural Residues and Energy Crops	PM/PM_{10} $PM_{2.5}$	0.74 0.13	0.004 0.0007	Fabric Filter Baghouse

V. BACT ANALYSIS OF BOILER FUEL AND BOILER MATERIALS HANDLING OPERATIONS

A. Source Description

The boiler fuel (e.g., biomass, enzymatic hydrolysis residuals including lignin-rich stillage cake and thin stillage syrup, particles collected during grinding/milling, non-condensible gases (NCG) vent streams, wastewater treatment sludge, and biogas) and the boiler materials handling operations (e.g., boiler bottom ash collection system, boiler fly ash collection system, and lime handling system) are sources of $PM/PM_{10}/PM_{2.5}$ emissions which are emitted as point source emissions. .

Positive displacement blowers pneumatically transfer the ground agricultural residues or energy crops to the boiler fuel live-bottom metering bins that gravity-feed the biomass to the boiler. Other conveyor systems will feed the wastewater treatment sludge and enzymatic hydrolysis lignin-rich stillage to the metering bins. There will be no separation of solid biomass in the metering system employed to feed the biomass-fired stoker boiler. The collected fly ash will be conveyed to the fly ash storage silo for rail or truck loadout

Generally the entire boiler fuel and materials handling operations will be closed systems designed with high velocity pickup of particles; therefore, a capture efficiency of 100% is anticipated. The boiler fuel and materials handling systems will aspirate to fabric filter dust collectors (baghouses) for control of particulate emissions.

B. PM/PM_{10} BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems;

   b. Pneumatic conveying of materials through pipes and duct work; and,

   c. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

      i. Fabric Filter Baghouse;
      ii. Wet ESPs;
      iii. Dry ESPs;
      iv. Venturi Scrubbers; or
      v. Cyclones

2. Eliminate Technically Infeasible Control Options

   Enclosures reduce particulate emissions by containing the material and preventing release of particulates or by reducing the wind that can entrain small exposed particles. Enclosures are typically used to capture emissions from operations like grinding and material transferring/handling so that the dust emitted can be collected and vented to a control device.

   Types of enclosures typically used for handling dry solids are buildings, silos, hoppers, bins and conveyor covers. In the case of building enclosures, the degree of control is proportional to the degree to which the operation is enclosed. However, in well designed systems, these types of enclosures are totally enclosed.

   Solid transfer operations include gravity and pneumatic flow, conveying on belts, front-end loaders and buckets. Pneumatic flow is always enclosed in pipes. All the other types of transfer operations can be conducted with or without enclosure.

   Due to health and safety reasons, most enclosed operations require ventilation to remove the particulates generated by the operations. Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures, or pipes and duct work, is the fabric filter baghouse. A baghouse has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air.

Other control devices, such as ESPs, induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Wet ESPs, Venturi scrubbers and cyclones are considered technically feasible for use in the receiving operations.

3. Rank Technically Feasible Control Options

A baghouse, wet ESP and Venturi scrubber are all capable of achieving emissions reductions of 99% or more when employed with an enclosure or pipes and duct work. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency; and a wet ESP or Venturi scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste. Venturi scrubbers will be utilized in the process design for control of PM when the collected PM can be recovered and either reintroduced into the process stream for further processing, or when the collected PM is viewed as trash (i.e., dirt or other material that will interfere with production). Systems equipped with Venturi scrubbers will also be designed with baghouse control; therefore, the baghouse is the final dust control system of the exhaust stream.

Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology. Enclosures, piping and duct work must be maintained under negative pressure to achieve maximum control. Negative pressure is created by exhausting air, which is subsequently controlled by a baghouse.

Control Technology	Reduction Efficiency
Enclosure	50% to 99+%
Pipes and Duct Work	99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the boiler fuel and materials handling operations.

The most effective, technically feasible option identified for control of the emissions from the fuel and materials handling operations is the use of a baghouse.

5. Establish BACT

Based on the review of EPA's RBLC, recent PM/PM_{10} BACT limits range from 0.002 to 0.01 gr/dscf. In all of the RBLC cases, the BACT limits for these sources are based on the use of a baghouse to control the PM/PM_{10} emissions. The use of an enclosed system equipped with a baghouse is technically feasible for all systems associated with the boiler fuel and materials handling operations. Table B-11 lists the $PM/PM_{10}/PM_{2.5}$ proposed BACT limits. The $PM_{2.5}$ emission limits are based on the estimated weight fraction used to estimate potential emissions (either 17% by weight or 50% by weight $PM_{2.5}$).

Table B-11. Boiler Fuel and Materials Handling Operations

$PM/PM_{10}/PM_{2.5}$ Proposed BACT Limits

Stack ID	Equipment/ Process	Material Processed	Pollutant	Emission Rate (lb/hr)	Proposed BACT Emission Limit(s) (gr/dscf)	BACT Device(s) or Operational Limitation(s)
EP-11711	Boiler Feed System DC	Agricultural Residues and Energy Crops	PM/PM_{10} $PM_{2.5}$	0.74 0.13	0.004 0.0007	Fabric Filter Baghouse
EP-20514	Boiler Bottoms Ash Handling DC #1	Boiler Bottoms Ash	PM/PM_{10} $PM_{2.5}$	0.96 1 0.48	0.004 0.002	Fabric Filter Baghouse
EP-20510	Boiler Fly Ash Handling DC #1	Boiler Fly Ash	PM/PM_{10} $PM_{2.5}$	0.48 0.24	0.004 0.002	Fabric Filter Baghouse
EP-20520	Boiler Fly Ash Handling DC #2	Boiler Fly Ash	PM/PM_{10} $PM_{2.5}$	0.48 0.24	0.004 0.002	Fabric Filter Baghouse
EP-20512	Lime Handling DC #1	Boiler Sorbent	PM/PM_{10} $PM_{2.5}$	0.07 0.03	0.004 0.002	Fabric Filter Baghouse
EP-02710	Bulk Fly Ash Load-Out Silo	Boiler Fly Ash	PM/PM_{10} $PM_{2.5}$	0.96 0.48	0.004 0.002	Fabric Filter Baghouse
EP-02711	Bulk Fly Ash Load-Out Silo Spout	Boiler Fly Ash	PM/PM_{10} $PM_{2.5}$	0.96 0.48	0.004 0.002	Fabric Filter Baghouse

6. BACT Compliance

ABBK proposes to meet the agricultural residues and energy crops grinding and handling operations $PM/PM_{10}/PM_{2.5}$ BACT limit based on the average of at least three test runs conducted at each baghouse, and a visible emissions limit of 0% opacity.

VI. BACT ANALYSIS OF BULK FLY ASH LOAD-OUT

A. Source Description

Fly ash will be stored in the bulk fly ash load-out silo. Fly ash will be shipped off-site either by trucks or rail cars that are loaded from the elevated load-out silo system using a load-out spout. The load-out spout will be either sealed to the rail car or truck and maintained under negative pressure, or loadout will occur within a total enclosure, either of which will be controlled by the bulk fly ash load-out silo spout dust collector (DC-02711). There will be no fugitive emissions generated from this activity.

B. PM/PM_{10} BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems; and,

   b. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

      i. Fabric Filter Baghouse;
      ii. Wet Electrostatic Precipitators (ESPs);
      iii. Dry ESPs;
      iv. Venturi Scrubbers; or
      v. Cyclones.

2. Eliminate Technically Infeasible Control Options

   All of the available control options listed above, except the use of dry ESP, are technically feasible for controlling the fugitive $PM/PM_{10}/PM_{2.5}$. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Thus, use of dry ESP is eliminated in this BACT analysis.

3. Rank Technically Feasible Control Options

   The reduction in emissions from the decrease in wind velocity due to an enclosure is expected to be up to 100% when compared to processes in the open. A baghouse, wet ESP and Venturi scrubber are all capable of achieving additional emissions reductions of 99% or more. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency; and a wet ESP or Venturi scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste.

Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology.

Control Technology	Reduction Efficiency
Partial or Total Enclosure	50% to 99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the fly ash handling operations. There was limited information contained on the RBLC database that was specific to fly ash load-out to trucks.

5. Establish BACT

As previously stated, the load-out spout will be either sealed to the rail car or truck and maintained under negative pressure, or loadout will occur within a total enclosure. This type of control is consistent with recent BACT determinations for similar sources.

6. BACT Compliance

A Fugitive Dust Control Plan will be developed and will detail the work practices to be implemented to reduce fugitive emissions from the fly ash load-out operations. ABBK will provide a copy of the Fugitive Dust Control Plan and associated documentation to KDHE upon request to demonstrate compliance with BACT.

VII. BACT ANALYSIS OF BIOMASS FERMENTATION AND DISTILLATION

A. Source Description

The CO_2 generated from the biomass co-fermentation process (Area 16000) will be routed through the enzymatic hydrolysis fermentation CO_2 scrubber (S-18185). The rated control efficiency will be equal to or greater than 99%. The CO_2 generated from the biomass ethanol recovery process (Area 18000) will be routed through the enzymatic hydrolysis distillation vent scrubber (S-18180). The distillation vent scrubber vent feeds into the enzymatic hydrolysis fermentation CO_2 scrubber (S-18185) for further control efficiency. The non-condensibles generated in areas 12000, 16000, and 19000 from the biomass process vents will be routed to either the biomass-fired boiler or flare for destruction.

The vent streams routed to the scrubbers are expected to be saturated with water since the process tanks contain primarily CO_2 and water. These vent streams also are expected to contain VOC and HAPs. The scrubbers will be packed-tower wet scrubbers, which allow for ethanol vapors to be collected in order for a higher product yield; however the units also provides VOC and HAP emission control. The scrubber systems will recover nearly all of the ethyl alcohol (ethanol) from the vapor stream and return the ethanol to the process downstream. The water from the wet scrubbers is pumped back into the process for recycling. The distillation vent scrubber vent feeds into the enzymatic hydrolysis fermentation CO_2 scrubber (S-18185) for further control efficiency and is discharged through the fermentation CO_2 scrubber stack (EP-18185).

A detailed engineering evaluation of the fermentation and distillation vent streams identified the potential for other PSD pollutants, including condensable PM, NO_2 and H_2S. Although this source's VOC and H_2S emissions do not require PSD review, the condensable PM and NO_2 must undergo PSD review. It should be noted that the wet scrubbers are an integral part of the process, as well as a control device for VOC, HAPs, PM, H_2S and NO_2. Wet scrubbers allow for product that would otherwise be lost in the vent streams to be captured and returned to the process stream. Wet scrubbers increase the efficiency of the process and the biorefinery would not operate without the wet scrubbers.

B. Condensable PM and NO_2 BACT Review

1. Identify Available Control Options

   Condensable PM is formed after the stream exhausts from the scrubber and is due to fine particles, including aerosols, condensing at ambient air conditions. Wet scrubbers often achieve higher levels of condensable PM control as the scrubbers help to condense the condensable PM during the scrubbing. NO_2 is a trace containment present in the vent streams ducted to the fermentation packed-tower wet scrubber for control. NO_2 control through the use of the scrubber is estimated to be greater than 95% control.

   Packed-tower wet scrubbers been identified and considered in determining BACT. A packed-tower wet scrubber is an absorption system in which the waste stream is dissolved by passing it through a medium containing a solvent. Water is the most commonly used solvent. Other solvents may be used depending on the components of the waste stream. Also, application of a wet scrubber in the ethanol production process is used to increase the process efficiency. This technology is considered technically feasible.

   Based on the review of the RBLC database and other technical sources of information, there are no additional control options for condensable PM and NO_2 in addition to the packed-tower wet scrubbers that will be employed as part of the fermentation and distillation process.

2. Establish BACT

Based on the use of the packed-tower wet scrubbers for VOC and HAP control, the most effective, technically feasible option identified for the control of condensable PM and NO_2 is also the use of packed-tower wet scrubbers only for the fermentation and distillation operations associated with ethanol production. **Table B-12** lists the proposed BACT limits.

Table B-12. Fermentation and Distillation Operations - PM and NO_2 Proposed BACT Limits

Stack ID	Equipment/ Process	Emission Rate (lb/hr)	Proposed BACT Emission Limit(s) (lb/hr)	BACT Device(s) or Operational Limitation(s)
EP-18185	EH Fermentation CO_2 Scrubber	Condensable PM: 0.10 NO_2: 0.08	Total PM: 0.1 NO_2: 0.07	Wet Scrubber

ABBK proposes that the pound per hour limits be considered BACT and used for compliance purposes for enzymatic hydrolysis fermentation CO_2 scrubber (S-18185). The proposed BACT limits in pound per hour applies during all times, including during SSM, and are based on an average across the fermentation batch cycle during the performance testing of the source.

The proposed BACT limit is in units of pounds per hour, rather than a throughput based limit for several reasons. First, the estimated scrubber performances are based on a 95+% control of NO_2 emissions, as calculated using material balance data at the wet scrubbers and a process simulator program. When outlet concentrations are lower, percent control efficiencies may decline slightly; however, the lb/hr emission rate would also decline. Second, there are multiple vent streams entering the scrubbers. Thus, it would be difficult to develop a single throughput based limit for the wet scrubbers that can account for these vents. Third, the condensable PM and NO_2 emissions from the fermentation and distillation operations vary for a number of reasons including the fermentation process in batch mode, thus throughput is not necessarily a good indication of emissions. Finally, the ability to determine compliance with a throughput based limit is extremely difficult due to the factors involved in determining both emissions and throughput. The ability to determine compliance with a pound per hour limit is readily demonstrated using standard EPA test methods.

VIII. BACT ANALYSIS OF FLARE (EP-09001)

A. Source Description

The facility design will incorporate a flare (EP-09001) for control of process vents flow, biogas and product loadout vapors. The vent streams will normally be vented to the biomass-fired boiler for combustion; however biogas may be vented to the flare as needed for up to 3,960 hours per year.

B. PM/PM_{10}/$PM_{2.5}$, NOx, CO, VOC, and SO_2 BACT Review

1. Identify Available Control Options

   The following control options have been identified and considered in determining BACT:

   a. Flare; and

   b. Fuel Gas in Other Facility Processes.

2. Eliminate Technically Infeasible Control Options

   There are no other combustion sources at the facility except for the biomass-fire boiler. Flaring is the only technically feasible option available when the vent streams cannot be vented to the boiler.

3. Evaluate Technically Feasible Control Options

   Flares can be used to control almost any hydrocarbon (including VOC) laden streams and can handle fluctuations in hydrocarbon (including VOC) concentrations, flow rate, heat content, and inert content, provided that the gas has a heating value greater than 300 Btu/scf.

   Flaring is appropriate for continuous, batch and variable flow vent stream application. Some streams, such as those containing halogenated or sulfur-containing compounds, are usually not flared because they corrode the flare tip or cause formation of secondary pollutants (such as acid gases or sulfur dioxide). A flare normally provides a VOC destruction efficiency of greater than 98% and is considered technically feasible. Because flares are primarily safety devices which deal with flows of short durations (generally an upset condition or an accidental release from a process) rather than a control device which treats a continuous waste stream, it is not entirely appropriate to compare the cost effectiveness of flares to other control devices. Cost per ton of pollutant controlled largely depends upon the annual hours of operation.

   Emissions from flaring include carbon particles (soot), unburned hydrocarbons, CO, and other partially burned and altered hydrocarbons. Also emitted are NOx and, if sulfur-containing materials are flared, SO_2. The quantities of hydrocarbon emissions generated relate to the degree of combustion. The degree of combustion depends largely on the rate and extent of fuel-air mixing and on the flame temperatures achieved and maintained.

   Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the exhaust gas stream. The tendency of a fuel to smoke or make soot is influenced by fuel characteristics and by the amount and distribution of oxygen in the combustion zone. For complete combustion, at least the stoichiometric amount of oxygen must be provided in the combustion zone. Complete combustion to reduce soot requires sufficient combustion air and proper mixing of air and waste gas.

EPA's RBLC database was reviewed to identify other potential control technologies that were potentially applicable to flares. The BACT control technologies included low NOx burners, fuel sulfur content limits, and good combustion practices.

4. Establish BACT

There are no known technically feasible control options available in addition to flaring; therefore, BACT is the use of a flare.

ABBK proposes that the BACT limits for the biogas flare consist of the following:

a. Hours of operations limit to 3,960 hours per year;
b. Limit pilot fuel to natural gas;
c. Smokeless design;
d. Treatment of biogas to remove sulfur to $\leq$100 ppm;
e. Use of low NOx burner; and
f. Good combustion practices.

IX. BACT ANALYSIS OF FIREWATER PUMP ENGINE (EP-6001)

A. Source Description

One 460 horsepower (Hp) (343 kilowatt (kW)) firewater pump engine will be installed at the facility to protect personnel and equipment in the event of a fire. The firewater pump engine will combust diesel fuel and meet the New Source Performance Standard (NSPS) regulation, 40 CFR Part 60, Subpart IIII, *Standards of Performance for Stationary Compression Ignition (CI) Internal Combustion Engines (ICEs)*. The emergency engine is assumed to operate less than 100 hours per year for maintenance checks and readiness testing to qualify as emergency engines under NSPS Subpart IIII (40 CFR Part 60 Section 60.4211(e)).

B. PM/PM_{10} BACT Review

1. Identify Available Control Options

PM/PM_{10} emission controls for limited use diesel fuel-fired CI engines that have been identified and considered in determining BACT include the following:

a. Advanced engine design (per NSPS Subpart IIII) with combustion optimization;
b. Diesel oxidizations catalysts (DOC); and
c. Diesel particulate filters (DPF) or catalyzed diesel particulate filters (CDPF).

2. Eliminate Technically Infeasible Control Options

The use of DOCs, DPFs and CDPFs are not considered technically feasible because these types of control devices cannot be applied to limited-use engines like the proposed emergency diesel fuel-fired CI engine.

The emergency diesel fuel-fired engine that will be installed at the facility will meet specific design emission standards that are mandated by the NSPS Subpart IIII regulations, and these specific engine standards are dependent on when the engine is purchased. The NSPS Subpart IIII standard is a mandatory function that ensures certain engine standards are met, and the "feasible" engine design standards will increase with time. It is this NSPS standard that serves as the basis for this BACT determination.

3. Rank Technically Feasible Control Options

Based on the above discussion, the only technically feasible PM/PM_{10} control technology identified for further evaluation as part of this BACT analysis is advanced engine design with good combustion control (combustion optimization).

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify PM/PM_{10} control technologies that were potentially applicable to limited use diesel fuel-fired engines.

The most effective, technically feasible option identified is the use of the NSPS standard.

5. Establish BACT

ABBK proposes to install diesel fuel-fired engines that meet the applicable NSPS diesel emission standards as detailed in NSPS Subpart IIII for the applicable model year (i.e. for the year the engine is purchased). ABBK will provide a copy of the manufacturer's certification to KDHE upon request to demonstrate compliance with BACT.

PM: 0.08 g/Hp-hr

C. NOx BACT Review

1. Identify Available Control Options

NO_x emission controls for limited use diesel fuel-fired CI engine that have been identified and considered in determining BACT include the following:

a. Advanced engine design (per NSPS Subpart IIII) with combustion optimization;
b. Exhaust gas recirculation for NOx reduction;
c. Lean-NOx catalyst technology;
d. NOx absorber technology;
e. Oxidation catalysts;

f. Selective catalytic reduction (SCR); and
g. Selective non-catalytic reduction (SNCR)

2. Eliminate Technically Infeasible Control Options

   Lean-NOx catalyst and NOx adsorber technologies have not been demonstrated to function efficiently on stationary CI engines or on sources with similar exhaust gas characteristics. SCR and SNCR technologies are not technically feasible for limited operation emergency use applications and have not been required for BACT/LAER on such applications.

   The emergency diesel fuel-fired engines that will be installed at the facility will meet specific design emission standards that are mandated by the NSPS Subpart IIII regulations, and these specific engine standards are dependent on when the engines are purchased. The NSPS Subpart IIII standard is a mandatory function that ensures certain engine standards are met, and the "feasible" engine design standards will increase with time. It is this NSPS standard that serves as the basis for this BACT determination.

3. Rank Technically Feasible Control Options

   Based on the above discussion, the only technically feasible NOx control technology identified for further evaluation as part of this BACT analysis is advanced engine design with good combustion control (combustion optimization).

4. Evaluate Technically Feasible Control Options

   EPA's RBLC database was reviewed to identify NOx control technologies that were potentially applicable to limited use diesel fuel-fired engines.

   The most effective, technically feasible option identified is the use of the NSPS standard.

5. Establish BACT

   ABHK proposes to install diesel fuel-fired engines that meet the applicable NSPS diesel Tier 3 emission standards. ABBK will provide a copy of the manufacturer's certification to KDHE upon request to demonstrate compliance with BACT.

   NO_x: 2.57 g/Hp-hr

D. SO_2 BACT Review

1. Identify, Eliminate, and Rank Available Control Options

   The only SO_2 control option identified for limited-use engines like the emergency diesel fuel-fired CI engine is the use of low sulfur diesel fuel. Based on the projected availability of diesel fuel that meets U.S. EPA mandated fuel sulfur standards, a diesel fuel sulfur content limit of 15 parts per million by weight (ppmw), equivalent to 0.0015% by weight is achievable.

2. Evaluate Technically Feasible Control Options

   EPA's RBLC database was reviewed to identify SO_2 control technologies that were potentially applicable to limited use diesel fuel-fired engines.

   The most effective, technically feasible option identified is the use of low sulfur distillate oil (≤0.0015% sulfur by weight).

3. Establish BACT

   ABBK proposes to limit the fuel use in its emergency diesel fuel-fired CI engines to ultra low sulfur distillate oil (≤0.0015% sulfur by weight).

   Due to the low rate of emissions from these emergency engines and the availability of diesel fuel that meets EPA mandated fuel sulfur standards, ABBK requests that BACT be established as the use of ultra low sulfur distillate oil (≤0.0015% sulfur by weight) rather than emission limits.

E. CO BACT Review

1. Identify Available Control Options

   a. Advanced engine design (per NSPS Subpart IIII) with combustion optimization;
   b. Catalytic oxidation; and
   c. Non-selective catalytic reduction (NSCR).

2. Eliminate Technically Infeasible Control Options

   The use of NSCR is not considered technically feasible because this type of control device has not been demonstrated to function efficiently on lean-burn ICEs. The use of catalytic oxidation is not considered technically feasible due to temperature considerations. Catalytic converters do not function well at off-temperatures, and limited use engines such as the firewater pump engine and power back-up generator, run only infrequently at the proper temperature for such systems to work.

The emergency diesel fuel-fired CI engines that will be installed at the facility will meet specific design emission standards that are mandated by the NSPS Subpart IIII regulations, and these specific engine standards are dependent on when the engines are purchased. The NSPS Subpart IIII standard is a mandatory function that ensures certain engine standards are met, and the "feasible" engine design standards will increase with time. It is this NSPS standard that serves as the basis for this BACT determination.

3. Rank Technically Feasible Control Options

   Based on the above discussion, the only technically feasible CO control technology identified for further evaluation as part of this BACT analysis is advanced engine design with good combustion control (combustion optimization).

4. Evaluate Technically Feasible Control Options

   EPA's RBLC database was reviewed to identify NOx control technologies that were potentially applicable to limited use diesel fuel-fired engines.

   The most effective, technically feasible option identified is the use of the NSPS standard.

5. Establish BACT

   ABBK proposes to install diesel fuel-fired engines that meet the applicable NSPS diesel emission standards as detailed in NSPS Subpart IIII for the applicable model year (i.e. for the year the engine is purchased). ABBK will provide a copy of the manufacturer's certification to KDHE upon request to demonstrate compliance with BACT.

   CO: 0.67 g/Hp-hr

X. BACT ANALYSIS OF IN-PLANT ROADS

A. Source Description

Abengoa Bioenergy will construct paved in-plant haul roads for delivery of biomass and other raw materials such as denaturant and process chemicals; as well as for shipment of products and by-products. Particulate emissions occur whenever vehicles travel over a paved surface, such as public and industrial roads and parking lots.

Abengoa Bioenergy plans to pave all in-plant haul roads associated with the ethanol production plant; therefore, only mitigation control measures applicable to paved roads are addressed in this BACT.

B. PM/PM_{10} BACT Review

1. Identify Available Control Options

The following control options are best management practices (BMPs) that have been identified and considered in determining BACT for the in-plant haul roads:

a. Posting and limiting vehicle speeds;
b. Use of wind fences or other wind breaks;
c. Water spray/road washing;
d. Chemical stabilization;
e. Sweeping; and
f. Combination of the controls identified above.

2. Eliminate Technically Infeasible Control Options

The above listed BMPs are all technically feasible and can be implemented at the site to mitigate particulate emissions.

3. Rank and Evaluate Technically Feasible Control Options

The combination of paved roads with wet suppression followed by vacuuming and/or sweeping represents the most effective control option for fugitive emissions. Control efficiencies of up to 95% can be achieved with frequent application. The second most effective control option is the combination of paved roads and either wet suppression or sweeping.

Control efficiencies for water flushing and sweeping are highly variable and dependent on application rates and frequency. In general, reported control efficiencies for both approaches fall into a range of 25% to 58% compared to a baseline of paved roads without mitigative controls. The control efficiency of water flushing with a high application rate and frequency may be higher than with sweeping alone. However, in comparison to sweeping, water flushing has several potential drawbacks, including high water usage, potential water pollution and the frequent need for the water truck to return to a water source, generating increased vehicle tailpipe emissions.

EPA's RBLC database was reviewed to identify PM/PM_{10} control technologies that were potentially applicable to paved in-plant haul roads.

According to EPA's RBLC database, paved in-plant haul roads with fugitive dust controls such as daily sweeping and/or washing is ranked as the top control and has been established as BACT technology for in-plant haul roads.

4. Establish BACT

Abengoa Bioenergy proposes that BACT for the in-plant haul roads consist of the following:

a. Paving of all in-plant haul roads;
b. Post and enforce a maximum speed limit of 15 mph;
c. Develop, maintain and implement a fugitive control strategy and monitoring plan;
d. No visible emissions beyond property boundary.

ABBK proposes that the paved in-plant haul road BACT limit be based on a truck traffic limit calculated using a 7-day rolling average and visibility monitored to ensure there are no visible emissions beyond the property boundary. Further, a Fugitive Dust Control Plan will be developed and will detail the work practices to be implemented to reduce fugitive emissions from the unpaved biomass laydown roads and unpaved staging area. ABBK will also provide a copy of the Fugitive Dust Control Plan and associated documentation to KDHE upon request to demonstrate compliance with BACT.

XI. BACT ANALYSIS OF BIOMASS LAYDOWN ROADS AND STAGING AREA

A. Source Description

ABBK will construct unpaved biomass laydown roads and an unpaved staging area for staging and storage of baled agricultural residues and energy crops. Similar to paved roads, particulate emissions occur whenever vehicles travel over a surface. The unpaved surfaces with have crushed and screened rock applied to strengthen the road surface and minimize fugitive dust.

B. PM/PM_{10} BACT Review

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT for the unpaved biomass laydown roads and an unpaved staging area:

a. Paving;
b. Posting and limiting vehicle speeds;
c. Use of wind fences or other wind breaks;
d. Water spray;
e. Chemical stabilization; and
f. Combination of the controls identified above.

2. Eliminate Technically Infeasible Control Options

Agricultural residues and energy crops are delivered in bale form exclusively on flatbed / module trucks to the facility. The baled biomass will either be unloaded directly onto conveyors supplying the grinding lines or unloaded at the biomass staging area or biomass storage field via the unpaved biomass laydown roads. The biomass staging area is utilized during the night shift and is located immediately adjacent to the biomass grinding lines to reduce traffic traveling in the biomass storage field. The biomass staging area and biomass storage field are constantly active as bales are brought onsite and stored as well as retrieved for use in the process during the night shift or during delivery disruptions.

Paving of the biomass laydown roads and staging area is not technically feasible due to the delivery method of the biomass bales. The module truck beds are designed such that the bed tips extends off of the truck bed and rests directly on the ground. Due to the loading/unloading of bales from the trucks directly to the ground, there is significant pressure applied at the edge of the truck bed and the ground surface. Paved surfaces will be substantially degraded by the pressure of the trucks beds, such that the paved surfaces are not expected to withstand the activities.

3. Rank Technically Feasible Control Options

The combination of water or chemical suppression represents the most effective control option for fugitive emissions. Control efficiencies of up to 70% can be achieved with frequent application. The second most effective control option is the combination of paved roads and either wet suppression or sweeping.

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify PM/PM_{10} control technologies that were potentially applicable to unpaved roads.

The most effective, technically feasible option identified for control of the fugitive emissions from unpaved haul roads is the use of water and chemical dust suppression with an enforced speed limit.

5. Establish BACT

ABBK proposes that BACT for the unpaved biomass laydown roads and an unpaved staging area consist of the following:

a. Post and enforce a maximum speed limit of 15 mph;
b. Develop, maintain and implement a fugitive control strategy and monitoring plan; and
c. No visible emissions beyond property boundary.

ABBK proposed that the unpaved biomass laydown roads and unpaved staging area BACT limit be based on a truck traffic limit calculated using a 7-day rolling average and visibility be monitored to ensure there are no visible emissions beyond the property boundary. Further, a Fugitive Dust Control Plan will be developed and will detail the work practices to be implemented to reduce fugitive emissions from the unpaved biomass laydown roads and unpaved staging area. ABBK will also provide a copy of the Fugitive Dust Control Plan and associated documentation to KDHE upon request to demonstrate compliance with BACT.